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Indian Standard

SPECIFICATION FOR ELECTRIC MOTOR OPERATED ACTUATORS

(*First Revision*)

UDC 621·3-52 : 65·011·56

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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March 1987

Indian Standard

SPECIFICATION FOR ELECTRIC MOTOR OPERATED ACTUATORS

(*First Revision*)

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Indian Standard

SPECIFICATION FOR ELECTRIC MOTOR OPERATED ACTUATORS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 24 July 1986, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This Indian Standard was published in 1979 and is being revised to incorporate modifications on requirements and test methods.

0.3 Electric actuators are electrically powered devices which are operated by some form of electrical control system and are used to position control elements, such as slide valves, control valves, butterfly valves, louvers, dampers, etc.

0.4 Depending on the operating principles, electric actuators are classified as: (a) electric solenoid operated types, and (b) electric motor operated types. Solenoid operated actuators provide only two position operation and are covered by IS : 8935-1985*. Motor operated actuators provide two position, multiposition or proportioning operation depending on the construction and the control system.

0.5 Actuators for special applications shall meet the conditions laid down in Appendix A in addition to those in the main specification, and in case of dispute, the provisions of Appendix A shall apply.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Specification for electric solenoid operated actuators (*first revision*).

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the requirements of electric motor operated actuators which are used in conjunction with open loop and closed loop control for operating the final control elements of industrial process control system.

1.2 This standard does not cover solenoid operated actuators which provide only two position control, and is covered by IS : 8935-1985*.

2. TYPES

2.1 Type 1 Multi-Turn Valve Actuators — For the multi-turn valve actuators, a wide variety in output shaft speed is realized by selecting motors with different rotational speeds and a variable reduction in spur and worm-gears. The multi-turn valve actuators are employed both for open loop control and closed loop control.

2.2 Type 1A Multi-Turn Valve Actuators for Open Loop Circuits — The multi-turn valve actuators designed for use in open loop control circuits normally run in short time operations between two final positions, 'open' and 'close'. Actuators can be used to reach a positioning time of few seconds up to several minutes.

2.3 Type 1B Multi-Turn Valve Actuators for Closed Loop Circuits — The actuators should be designed to enable stop of within ±45° from central position of valve. The gear units should be checked for minimum backlash and rigidness and are exclusively driven by motors with electromechanical or electrical brake. Motors with electromechanical brake are robust and designed for an extended period of operation.

2.4 Type 2 Part-Turn Actuators — The part turn actuators are provided with a second worm-gear. The specified positioning times for strokes of 90° or 120° are realized with the additional stages. The part turn actuators are employed for closed loop control and open loop control. The part turn actuators are used for operating butterfly valves, guide vanes in fans and positioning element in control loops.

2.5 Type 3 Multi-Turn Valve Actuators with Linear Output — These are constructed by assembling a multi-turn valve actuator with output shaft design and a linear stage with driving rod. The latter is readily fixed. These are used for applications which require a linear movement of the stem.

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*Specification for electric solenoid operated actuators (*first revision*).

3. PRINCIPLE OF OPERATION

3.1 Electric motor operated actuators basically consist of an electric motor with reduction gear and an output shaft or a level arm incorporated in a common housing. With automatic regulation and remote control, rotation is transmitted from the electric motor to the final control element.

4. CONSTRUCTION

4.0 General — The construction features of various actuators are given below.

4.1 Motor

4.1.1 Electric motor operated actuators are equipped with surface cooled 3-phase, 415 V, 50 Hz squirrel cage motors. Driving motors are of various sizes depending on power output requirement of actuator. Driving motors of most of the actuators are of reversible type induction motor.

4.1.2 Motors of actuators shall generally comply with the provisions laid down in IS : 325-1978*. The motors shall be short-time rated for not less than 15 minutes continuous operation and shall be suitable for direct in-line starting. (15 m rating allows the motor to provide 3 or 4 consecutive operations of a valve for which the travel time is likely to be of the order of 1 or 2 minutes). The motor shall be capable of starting at 85 percent of rated voltage and running at 80 percent of rated voltage at rated torque, and 85 percent of rated voltage at rated torque for a period of 5 minutes each. The starting current of the motors shall not exceed 6 times the full load current. Motors shall be provided with minimum Class B insulation and shall be suitable for dusty and corrosive atmospheres. They shall be painted with corrosion proof epoxy resin paint. Motors shall preferably be 'O' ring sealed for complete envimental protection.

4.2 Terminal Box — Terminal boxes shall be provided for termination of signal and power supply cables. The degree of protection of the signal terminal box shall be as given in IS : 2147-1962†.

4.2.1 All terminals of position limit switches, torque switches, space heaters and remote position transmitter shall be brought to a common terminal board. The terminal shall be of screw type with sufficient insulation between adjacent terminals.

---

*Specification for three-phase induction motors (*fourth revision*).

†Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

The terminal box of motor shall be capable of being turned through 360° in steps of 90° to facilitate cable entry from any direction. The terminal box of the actuator and motor shall have enough space for connecting two, 10 core PVC insulated armoured copper conductor cable of cross-section 2·5 mm^2 and one, 3 core PVC insulated armoured aluminium conductor cable of cross section 6 mm^2. Both the terminal boxes shall be weather-proof and be fitted with a removable cover plate in front.

4.3 Motor Flange — This part may be used for fastening the motor to the gear unit.

4.3.1 The dimensions of flanges shall preferably be as given in Table 1.

4.4 Gears

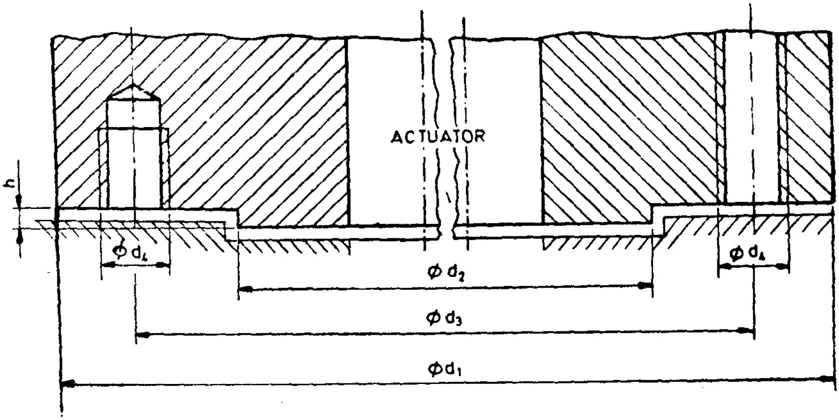
4.4.1 The gear is the main part of an actuator. It is of similar design for all types but it differs in dimensions according to the size of the actuators. The rotating movement of the motor is reduced in every actuator by means of a special worm-gear and if necessary, further reduction may be done using a planetary gear. As the number of revolutions is reduced, the torque will be increased. The output shaft may be hollow to accommodate rising valve stems and the complete output drive assembly shall permit the opening of gear case without releasing the stem thrust or removing the valve from service.

4.4.2 The output force of the motor is transmitted through a stage of spur gears, a spring balanced worm with axial bearings, a worm wheel and a clutch stage to the output shaft. The gear elements all run on suitable bearings and are accommodated in a lubricant filled cast housing. The actuator shall have proper seals to prevent leakage of the lubricant in the limit switch compartment and terminal box.

4.5 Handwheel Operation — Electric motor operated actuators should have the facility of handwheel operation. Whenever required, by pressing a change lever, the motor is uncoupled and the handwheel is coupled to the drive shaft. The mechanically independent handwheel drive is engaged by means of a clutch, which declutches the motor drive from the output shaft. When the motor starts, the handwheel shall be decoupled automatically and the motor is recoupled. Unless otherwise stated, clockwise operation of handwheel shall close the valve.

TABLE 1 FLANGE DIMENSIONS

(*Clause* 4.3.1)



Flange Type	Dimensions, mm					Number of Studs or Bolts
	d_1	d_2	d_3	d_4	*h, Max*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
F07	90	55	70	M8	3	4
F10	125	70	102	M10	3	4
F14	175	100	140	M16	4	4
F16	210	130	165	M20	5	4
F25	300	200	254	M16	5	8
F30	350	230	298	M20	5	8
F35	415	260	356	M30	5	8
F40	475	300	406	M36	8	8

NOTE 1 — The method of attachment may be by means of studs or through bolting. When the latter method is used, the diameter of the clearance holes shall permit the use of bolts of a size given by the corresponding d_4 dimension.

NOTE 2 — The holes for the studs/bolts shall be located off-centre and shall be equispaced.

NOTE 3 — The recess in the mounting surface corresponding to diameter, d_2, is mandatory; the spigot on the actuator is optional.

NOTE 4 — The dimension, d_1, has been based on giving sufficient landing for the nuts and bolt heads, where applicable. Such landing is defined as a radius from the bolt hole centre with the dimension $(d_1 - d_3)/d_2$, and shall be considered as a minimum. The shape of the flange of both valve and actuator outside of these areas of landing is left to the option of the manufacturer.

4.6 Standard Switching and Signalling Unit – The standard switching and signalling unit may be used as an accessory for the following purposes:

a) Protection of final control element against overloads;

b) Protection of motor;

c) Adjusting, signalling and limiting of stroke;

d) Remote transmission of actuator movement;

e) Remote transmission of actuator position; and

Winding thermostat may be provided as an additional protection.

4.6.1 *Torque Limit Switch* — The torque limit switch is constructed out of a mechanical transmission part and several microswitches or any other suitable mechanism. Each torque limit switch is actuated by an adjustable cam mechanism. The actuator shall have two torque switches, one for each direction of travel, namely, open and close. The limit switches shall have at least one normally open and one normally close contact. The switching capacity of these switches shall be at least 5 A on 250 V ac on resistive load and 0·5 A on 250 V dc.

4.6.2 *Travel Limit Switch* — Certain valves require travel limit switches in order to prevent sticking of the valve in its seat. Travel limit switches are either actuated by a roller counter mechanism or by a cam disc mechanism.

4.6.3 *Local Position Indicator* — A mechanical position indicator may be directly mounted inside the enclosure of the switching and signalling unit.

4.6.4 *Remote Indication* — Depending upon the application, the following transmitters may be used in actuators for electric remote indication:

a) One or more slide wire potentiometer, and

b) Electronic position transmitter.

The slide wires are mainly used for remote indication. They are driven by the adapter gear unit and, in standard design, feature a change in output of 0 to 100 ohm.

The electronic position transmitter is normally used for feedback in control loops or if more than one instrument controller, indicator, recorder, etc, have to be connected to the same information source.

4.6.5 *Space Heaters* — The switching and signalling unit of an actuator may be equipped with a space heater if environmental conditions pose the danger of water condensation inside the enclosure.

4.7 Brake

4.7.1 *Electromechanical Brake* — The motors with electromechanical brake shall be equipped with a disc brake which is controlled by a permanent magnet. The braking force should be according to the rating of the motor. The brake shall be mounted inside the ventilator hood.

4.7.2 *Capacitor Brake* — The servomotor designed to operate in automatic control system shall be provided with capacitor brakes for reducing the running out angle of the output shaft.

4.8 Internal Wiring — Internal wiring diagram printed on a corrosion resistant sheet shall be attached on the inside cover of the terminal box.

5. TECHNICAL REQUIREMENTS

5.1 Response Time — Response time of electric motor operated actuators are usually expressed in seconds for full travel and shall be available in a variety of speeds ranging from approximately 2 to 240 seconds for full travel. It shall be declared by the manufacturer.

5.2 Ambient Temperature — The permissible temperature for actuators is 0 to 60°C for standard designs; for explosion-proof actuators, these limits are -20 to $+40$°C.

5.3 Humidity — The permissible relative humidity for actuators of standard designs shall be up to and including 95 percent.

5.4 Travel Stroke — Travel/angular rotation of electric motor operated actuators differs with different actuator designs. The manufacturer shall specify the travel stroke.

5.5 Supply Voltage — Unless otherwise specified, the actuators shall be designed for nominal voltage of 240/415 V ± 6 percent at 50 Hz ± 3 percent.

5.6 Power Rating — The power drawn by the electric actuator will depend upon its design. The manufacturer shall specify the power rating.

5.7 Current — The starting current, the normal current and the stalling current shall also be specified by the manufacturer.

5.8 Limit Switches — Electric actuators shall be provided with open and close torque switches and/or, limit switches as required by the type of valve and two additional limit switches, one at each end of travel for remote indication and interlocking purposes. The switches shall be either changeover types or make and break contacts types. Independent intermediate switches shall be provided, when necessary. Means shall also be provided to prevent the open torque switch tripping while the initial unseating hammer blow effect is applied. Also, once the torque switch actuates and trips, the motor shall not reset until the motor is energized in the opposite direction.

6. MOUNTING

6.1 There is no restriction on the mounting position of the actuator. However, it is preferable to mount rotary and linear actuators with the output shaft downwards. The optional position of the part turn actuator is with its output shaft in horizontal position.

7. ACTUATORS USED IN EXPLOSION-HAZARDOUS AREAS

7.1 If actuators are used in explosion-hazardous areas, they shall be designed in such a way that they can never be the ignition source of an explosion. Depending upon the environmental conditions, motor is to be chosen in a suitable protection class (*see also* IS : 2148-1981*).

8. PACKING AND MARKING

8.1 Packing — Actuators shall be packed in wooden or other suitable containers so as to avoid damages during transportation.

8.2 Marking — The marking shall be clear and indelible.

8.2.1 The motor shall be marked with the following information:

a) Power rating,
b) Locked motor current,
c) Rated torque current,
d) Average load current,
e) Supply voltage,
f) Speed of the motor,
g) Insulation class, and
h) Protection class.

8.2.2 The actuator shall be marked with the following information:

a) Actuator type;
b) Actuator serial number;
c) Wiring diagram;
d) Torque range, Nm;
e) Maximum thrust, kN;
f) rpm of output shaft;
g) Set torque open/close;
h) Maximum stem diameter, mm;
j) Starting torque; and
k) Response time.

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*Specification for flameproof enclosures of electrical apparatus (*second revision*).

8.2.3 The motor operated actuator may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

8.3 Manufacturer shall provide instructions for lubrication and maintenance of actuator.

9. TESTS

9.1 General

9.1.1 *Type Tests* — The following shall constitute type tests:

a) Life test (**9.3**),
b) Response time test (**9.4**),
c) Variation of supply voltage (**9.5**),
d) Tests for motor (**9.6**),
e) Variation of frequency (**9.7**),
f) Test for limit switches (**9.8**),
g) Tests on output shaft (**9.9**),
h) Tests for terminal boxes (**9.10**), and
j) Damp heat cycling test (**9.11**).

9.1.2 *Routine Tests* — The routine tests shall constitute the following and shall be conducted on all actuators:

a) Functional and calibration test for torque and limit switches (**9.2**),
b) Response time test (**9.4**),
c) Variation of supply voltage (**9.5**),
d) Variation of frequency (**9.7**), and
e) Tests for motor (**9.6**).

9.1.3 *Acceptance Tests* — The acceptance test shall constitute the following:

a) Life test (**9.3**),
b) Response time test (**9.4**),

c) Variation of supply voltage (**9.5**),
d) Tests for motor (**9.6**),
e) Variation of frequency (**9.7**), and
f) Test on output shaft (**9.9**).

9.1.3.1 *Sampling plan* — A recommended sampling plan and the criteria for acceptance of the lot are given in Appendix B.

9.2 Functional and Calibration Test for Torque and Limit Switches — The operation and checking of calibration of these switches shall be carried out.

9.3 Life Test — The actuator shall be mounted with the output shaft, either vertical or horizontal, and operated for not less than 500 times, at the rated voltage as given in **5.5**. After the test, the actuator shall not suffer any deterioration so as to affect its satisfactory performance and shall conform to the requirements specified in this standard.

9.4 Response Time Test — The response time shall be verified with the actuator operated at rated voltage and frequency and shall conform to the value declared by the manufacturer (*see also* **5.1**).

9.5 Variation of Supply Voltage — A variation of supply voltage of ±6 percent from the reference voltage shall not affect the operation of the actuator with respect to the requirements specified in **5.1**, **5.4** and **5.6**.

9.6 Tests for Motor — The motor of the actuator shall generally be according to IS : 325-1978*.

9.6.1 *Routine Test for Motors* — The motor shall be tested for relevant requirements of routine and acceptance tests as given in IS : 325-1978*, except the test for locked rotor readings of voltage, current and power output.

NOTE — The test shall be carried out before assembly.

9.6.2 *Type Test for Motors* — The motor shall be tested for the following type tests as given in IS : 325-1978*:

a) Insulation resistance test;
b) High voltage test;
c) Full load reading of voltage, current, power input and slip;
d) Temperature-rise test; and
e) Test for verification of requirements as given in **4.1**.

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*Specification for three-phase induction motors (*fourth revision*).

9.7 Variation of frequency — A variation of ±3 percent in the frequency of the reference voltage shall not affect the operation of the actuator with respect to the requirements specified in **5.1**, **5.4** and **5.6**.

9.8 Tests for Limit Switches

9.8.1 The limit switches shall be subjected to the number of cycles of operation as given below after which they shall still be capable of normal operation:

Breaking Current, A	*Number of Cycles of Operation in Millions*
1	15
3	5
6	2·5
10	1

Snap-action type limit switches shall be subjected to 70 percent of the number of cycles of operation specified above.

9.8.2 *Making and Breaking Capacities* — The rated making capacity of the contacts of the limit switch shall be 90A. The rated breaking capacity shall be as given below:

ac 40 *to* 60 *Hz* *Power Factor* 0·3 *to* 1			*dc*				
Voltage Rating	Breaking Capacity		Voltage Rating	Breaking Capacity			
	Snap action	Others		Non-Inductive Load		Inductive Load	
				Snap action	Others	Snap action	Others
V	A	A	V	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
24	30	60	24	7	10	7	10
125	30	60	110	1·5	2·2	0·91	1·3
220	30	60	220	0·62	0·9	0·28	0·4
380	30	60	440	0·28	0·4	0·14	0·2
500	30	40	600	0·21	0·3	0·1	0·14

9.8.3 *Frequency of Operation* — Limit switches shall be capable of 6 000 operations in 1 hour.

9.9 Tests on Output Shaft — The output shaft of the actuator shall be capable of operating with an axial load of

$$\frac{2 \times \text{Maximum rated torque}}{\text{Diameter of the output shaft}}$$

9.10 Tests for Terminal Boxes — The terminal boxes provided shall satisfy the relevant test requirements specified in IS : 2147-1962*.

9.11 Damp Heat Cycling Test — This test shall be carried out as given in IS : 9000 (Part 5/Sec 1)-1981† with the severities as under:

Upper temperature : 55°C
Number of cycles : 6

APPENDIX A

(*Clause* 0.5)

ACTUATORS FOR SPECIAL APPLICATIONS

A-1. FOR NUCLEAR GENERATING STATIONS

A-1.1 Actuators for use in nuclear power generating stations have to meet very stringent requirements concerning quality and dependability. Besides the normal environmental conditions, the actuators will be exposed to high temperature and nuclear radiation. Even in case of an accident inside the containment of the reactor, the actuators should maintain their suitability over an extended period.

A-1.2 Nuclear Radiations — A continuous dose of nuclear radiation may cause extensive wear of several components inside the actuator, mainly cable insulation and lubricants, which will reduce the technical life span of the actuator. The wear may be reduced by using special material on lubricants. An effort should be made by manufacturers to limit the use of organic materials.

A-1.3 Temperature Conditions

a) Up to 120°C — motor in insulation class F, and
b) Up to 130°C — motor in insulation class H.

---

*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

†Basic environmental testing procedures for electronic and electrical items: Part 5 Damp heat (cyclic test).

A-1.4 Surface Treatment — All equipment inside the contianment of a reactor may be contaminated by radioactive dust, the actuator should be able to withstand a cleaning spray which is normally used for decontamination purposes. The type of protection provided shall be IP 55 (*see* **4** of IS : 2147-1962*). The actuators mentioned should have special primer and decontaminable paint. Actuators should have maximum earthquake resistance. The actuator design shall be such as to withstand a peak acceleration of 0·5 g over a frequency range of 1 to 33 Hz.

A-1.5 The following voltage and frequency conditions shall apply to motors used for actuators in nuclear applications:

a) The supply to the actuator motor shall be 415 V, 3 phase, 50 Hz, 3 wire system;

b) Motor shall start at a maximum of 80 percent of rated voltage;

c) Motor shall not stall when the supply voltage drops to 70 percent of rated voltage for a short duration of 25 cycles;

d) Motor shall be capable of withstanding the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150 percent of rated voltage, during fast changeover of the supply; and

e) Motor shall operate satisfactorily under the following conditions:

    1) Variation in frequency ±5 percent, ac supply voltage harmonic ±5 percent; and

    2) Variation in voltage ±10 percent, supply voltage imbalance ±3 percent.

APPENDIX B

(*Clause* 9.1.3.1)

SAMPLING OF ELECTRIC MOTOR OPERATED ACTUATORS

B-1. SCALE OF SAMPLING

B-1.1 Lot — In a consignment, all the actuators of the same type and rating manufactured from the same raw material under similar conditions of production shall be grouped together to constitute a lot.

---

*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

B-1.2 The number of actuators to be selected from each lot shall depend upon the lot size and shall be in accordance with col 1 and 2 of Table 2.

B-1.2.1 These actuators shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* shall be followed.

TABLE 2 SAMPLE SIZE AND PERMISSIBLE NUMBER OF DEFECTIVES

(*Clauses* B-1.2 *and* B-2.1)

LOT SIZE (1)	SAMPLE SIZE (2)	PERMISSIBLE NO. OF DEFECTIVES (3)
Up to 50	5	0
51 to 100	8	0
101 to 300	13	0
301 to 500	20	1
501 and above	32	1

B-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

B-2.1 The actuators selected at random according to col 1 and 2 of Table 2 shall be subjected to all the acceptance tests. The actuator failing to satisfy any of these requirements shall be considered as defective. The lot shall be considered as conforming to the requirements of this standard if the number of defectives found in the sample is less than or equal to the corresponding permissible number given in col 3 of Table 2; otherwise the lot shall be rejected.

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*Methods for random sampling.